CURRICULUM

SCIENCE... A PROCESS APPROACH II

PROGRAM GUIDE

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PREFACE

SCIENCE . . . A PROCESS APPROACH II is the first revision of the elementary science curriculum *Science . . . A Process Approach.* The new edition continues to emphasize the child's acquisition of skills in the processes of science. This *Program Guide* presents background information about the program, descriptions of its basic elements, suggestions for its use and its applicability to the broader curriculum, a summary research report, and a bibliography. In addition, the *Program Guide* provides guidelines for effectively teaching SCIENCE . . . A PROCESS APPROACH II.

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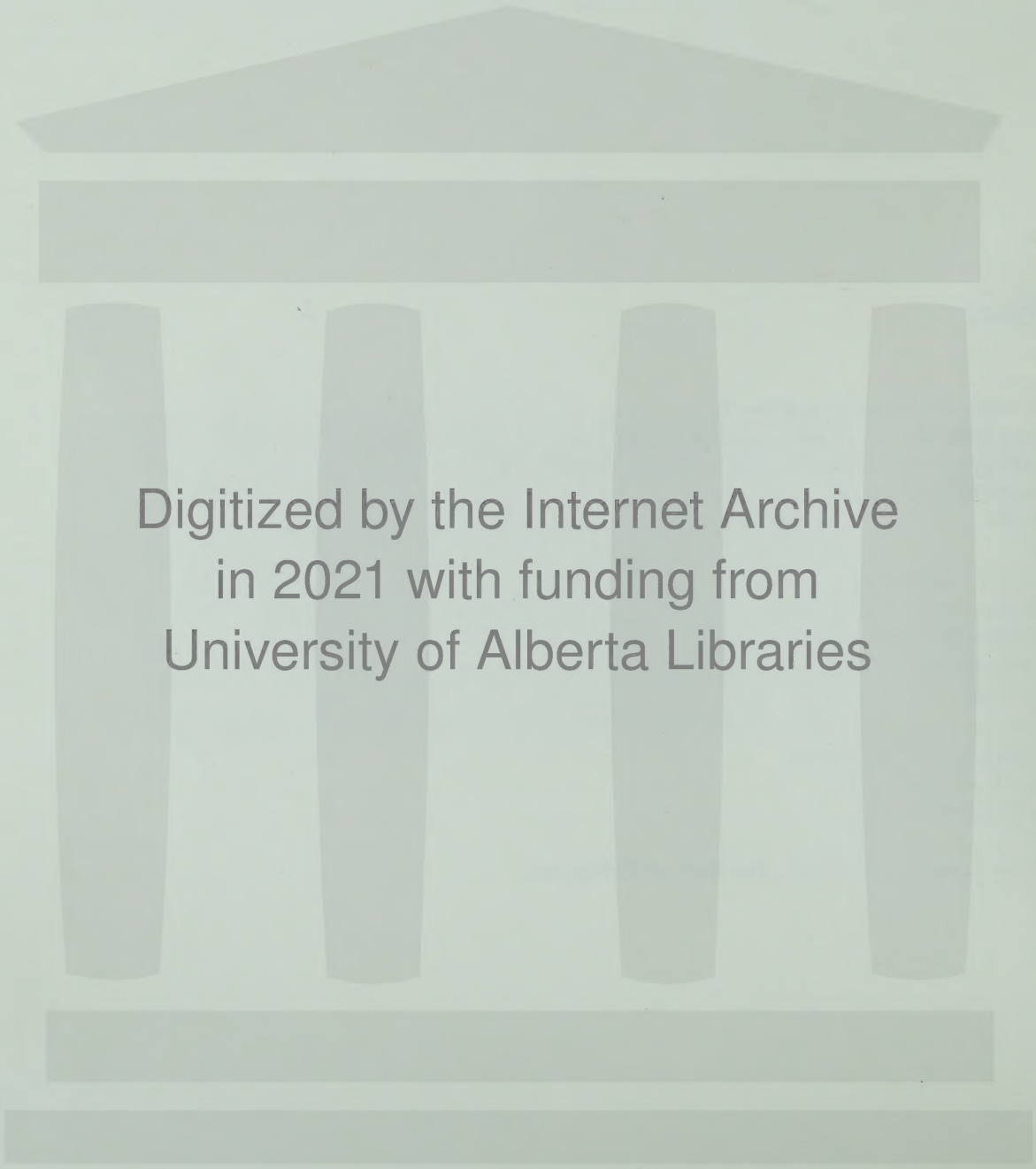
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WHY SCIENCE IN THE ELEMENTARY SCHOOL?

Science in the elementary school must contribute to the general education of every child. Through science children acquire methods of learning about themselves and the world. They learn scientific procedures for gaining *new* knowledge. They absorb attitudes of scientific inquiry. These skills and attitudes can provide a basis for later study of the sciences—or any other discipline. An individual so educated confronts a new issue or problem not so much by "What do I know?" as by "What can I do to find out what I need to know?"

A viable science program must enable children to reach a high level of achievement. Success in science can stimulate success in other areas. Children must be challenged by asking them frequently to think, to reason, and to invent. Such challenges stimulate independent thinking and self-reliance. Children's experiences must be broadened into many fields of science. Hopefully this broadening experience will result in a lasting interest in science, whether the individual chooses science as a life's work or not.

These are crucial goals. What better way is there to achieve them than by having children do what scientists do? Such a program can be built on the "processes" that a scientist uses in his or her work. These scientific processes are really ways of "processing information." We process information from our environment constantly. Such processing becomes more complex as the individual grows from early childhood to adulthood. The individual capabilities involved in processing can be called "intellectual skills."

A good instructional program in science must be realistic in developing intellectual skills. The goals to be achieved by any single part of the program must be modest. They must be clear and straightforward. Furthermore, there must be an orderly progression of learning experiences. The cumulative effect of this orderly progression—from a long-range view—will result in genuine growth.

DESIGNING A PROGRAM

SCIENCE . . . A PROCESS APPROACH II is designed to enable children to do what scientists do. Children acquire competence in the processes that scientists use. They learn how to view the world the way scientists do.

The program is best achieved through a laboratory, "hands-on" setup in which children are expected to seek out answers to questions. The teacher does not *tell* the outcomes to problems. The teacher guides the child to identify situations, to design a way to test ideas, to discover answers. Of course the teacher plays a central role in providing experiences that insure the learning of process skills in each exercise. Skills are developed as the child investigates various content areas.

Eight basic processes are identified in this program. These are:

- Observing
- Using Space/Time Relationships
- Classifying
- Using Numbers
- Measuring
- Communicating
- Predicting
- Inferring

There is progressive development within each process. At the earliest levels, the processes are discrete. They become increasingly interrelated as development continues. For example, the process *inferring,* which is introduced in Module 33, is closely related to the processes of observing, classifying, and measuring, which are taught in earlier modules.

Children develop skills in these basic processes in the early years. After they have acquired competence in the basic processes, they are ready to use these skills in the more complex, integrated processes of scientific activity. These processes are developed as the children investigate a variety of content areas. This program identifies these five integrated processes:

- Controlling Variables
- Interpreting Data
- Defining Operationally
- Formulating Hypotheses
- Experimenting

The process of *experimenting* is the focus of the final level of SCIENCE . . . A PROCESS APPROACH II. As the capstone of the integrated processes, experimenting involves the coordinated skills of all the basic and integrated processes.

Both the basic and integrated processes are described in greater detail on pages 26 to 29 of the *Program Guide,* in the *Commentary for Teachers,* in the filmstrips *Basic Processes* and *Integrated Processes,* which are part of the *Orientation Package,* and in the *Guide for Inservice Instruction*—all resource items for the teacher of SCIENCE . . . A PROCESS APPROACH II.

WHAT IS UNIQUE ABOUT SCIENCE . . . A PROCESS APPROACH II?

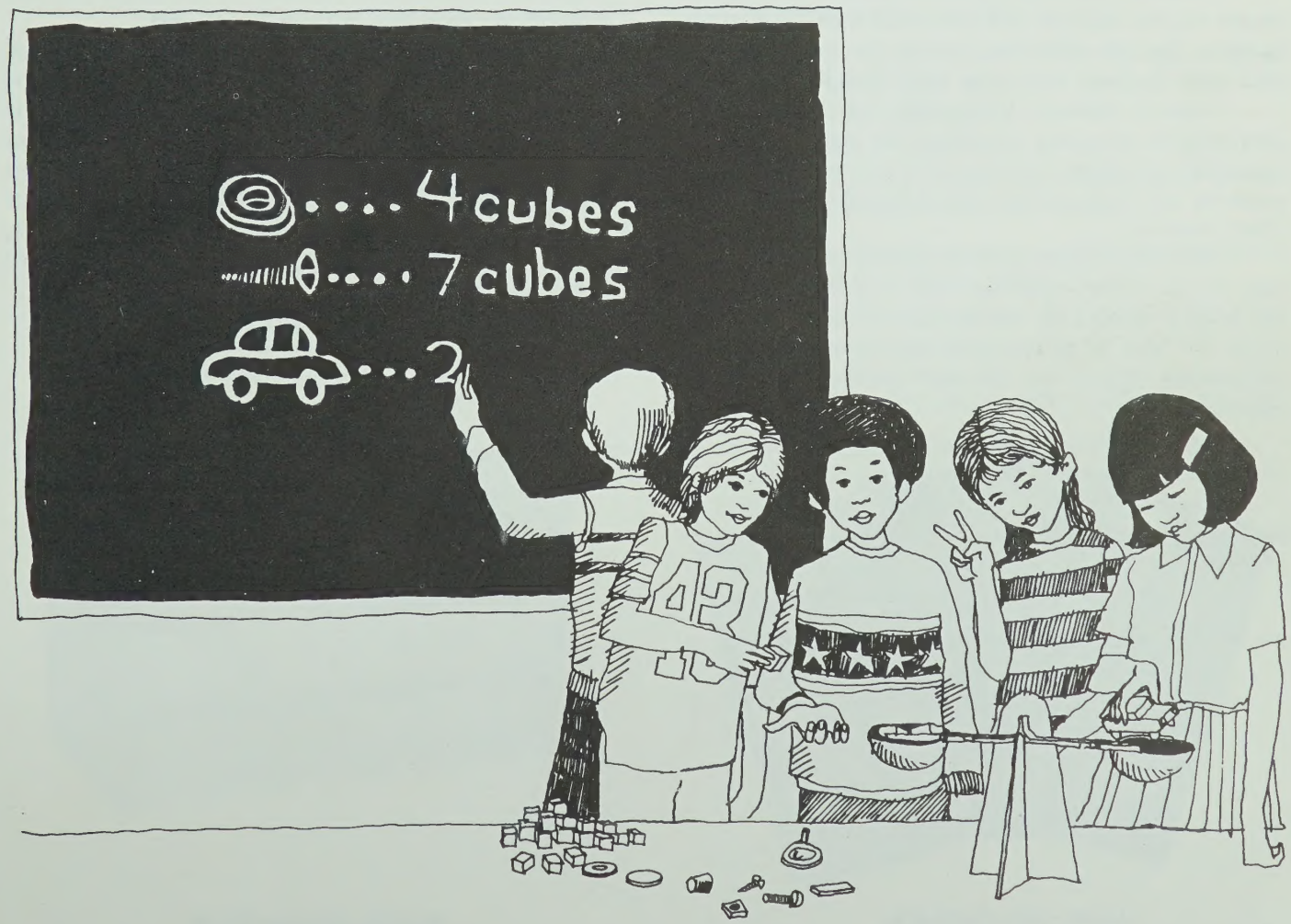
SCIENCE . . . A PROCESS APPROACH II has been developed after more than a decade of planning, experimentation, tryout, revision, and evaluation on a nationwide scale. It represents the successful culmination of a major experiment in education. The Commission on Science Education of the American Association for the Advancement of Science (AAAS), with support from the National Science Foundation over a six-year period, sponsored the original *Science . . . A Process Approach.* Its successor, SCIENCE . . . A PROCESS APPROACH II, is based on the experiences of teachers with the first edition.

Many new science experiences—some of which are auto-instructional—have been developed for the second edition. The new material has been extensively tested in the schools, then revised after field testing. The education staff of AAAS, assisted by scientists and teachers throughout the country, produced SCIENCE . . . A PROCESS APPROACH II with support provided by Ginn and Company.

In the revision, emphasis has been put on presenting alternative ways to achieve objectives. More stress has been placed on auto-instructional materials, on materials that can be used in peer-teaching situations, and on a variety of small-group activities. Open-ended, individualized extensions of activities have been enhanced. More ecological problems have been introduced. The basic elements of behavioral objectives and the evaluation of their achievement have been retained.

In addition to these distinctive features, a wide range of scientific content is introduced in many ways in SCIENCE . . . A PROCESS APPROACH II. The details of scientific content are as comprehensive as many might wish for an elementary science program. The major intent, however, is to develop competence in the scientific processes that underlie all scientific knowledge.

The process approach has a practical consideration: Scientific knowledge is increasing so rapidly that it is impossible for scientists themselves to keep up-to-date in all sciences. Certainly it is impossible for students to learn everything. To equip each child with skills that he or she can use to find solutions to scientific problems is an important strategy!



ORGANIZATION OF THE PROGRAM

SCIENCE . . . A PROCESS APPROACH II is made up of a series of instructional modules. Each module is devoted to a science process. A module consists of an *Instruction Booklet* for the teacher and a set of materials for the children. Each module has a process title and a code letter, which identify both the process and the position of that module in the process sequence. For example, *Observing c* is the third module devoted to the process *observing.* The modules also have a content title to identify the topic used to develop the process. Thus the title of *Observing c* is *Temperature.* Each module is also identified with a numeral to indicate its order in the sequence of all modules.

Fifteen modules constitute one year's work for most groups of children. However, many groups or individual children will proceed at a more rapid pace, and some will go more slowly. There is self-instructional material contained within many modules. Most of the others adapt easily to activity for individuals or small groups.

The *Instruction Booklet* provides the help the teacher will need for teaching the module. The booklet is made up of these parts:

Objectives state the minimal behaviors the children should acquire. Students will learn much more in doing the activities. But the objectives provide the teacher with a clear guide for basic instruction and a basis for evaluation.

Sequence indicates prerequisites for the module. It also identifies what later experiences are dependent on the successful achievement of the skills in the module. The sequence also suggests the relationship of these skills to other processes.

Rationale contains useful background information. It may include statements about the process skills and about the science content of the module. Sometimes there is advice on how to handle materials. In many cases the information reflects the practical experiences of other teachers.

Vocabulary lists new words and phrases that may be introduced in the module.

Instructional Procedure provides the teaching strategy. An *Introduction* suggests ways of arousing children's interest in the module. It gives the teacher clues about activities that will need special emphasis. *Activities* follow the *Introduction.* Each activity is described as to the tested ways the teacher and children can be involved to achieve the module's objectives. All activities need not be used. Optional activities can be used for enrichment or reinforcement. A *Materials* list follows each activity.

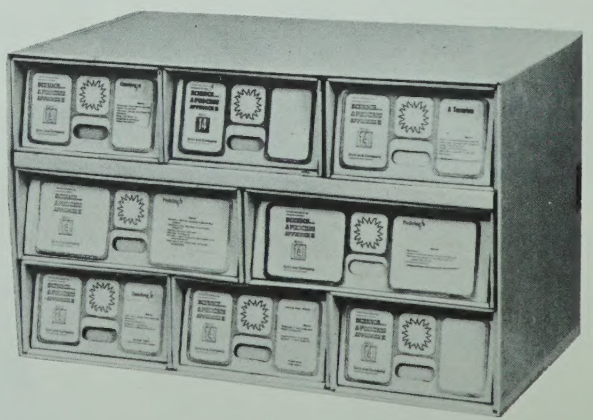
Generalizing Experiences provide an opportunity for the children to relate newly acquired skills to situations in different contexts.

The *Appraisal* in Modules 1 through 60 is planned group activity to help the teacher assess whether or not the children have acquired the behaviors prescribed in the *Objectives.* For Modules 61 through 105, the *Group Competency Measure* takes the place of the *Appraisal.*

Competency Measures consist of test items that can be administered in a specific way to individual children. Each item relates to an objective of the module. It uses different materials from those in the activities.

In addition to the *Instruction Booklet* and materials for the modules, each teacher should have a copy of the *Planning Chart* for SCIENCE . . . A PROCESS APPROACH II. This chart is especially useful for teachers who want to use an alternate order for teaching the modules. The *Planning Chart,* used with the individual module *Sequence* charts, will help the teacher find an effective learning sequence. The *Planning Chart* is discussed in greater detail later in the *Program Guide.*

Instruction Booklets



Module Storage Units

THE MODULES

There are 105 modules in SCIENCE . . . A PROCESS APPROACH II. The following list shows each module by numerical order, by process title, by process sequence, and by content title.

NO.	PROCESS	TITLE	OBJECTIVES
1	Observing/a	Perception of Color	1. *NAME* these colors: yellow, red, and blue. 2. *IDENTIFY* the following colors: yellow, orange, red, purple, blue, and green. 3. *IDENTIFY* other colors as being like one of these colors: yellow, red, or blue.
2	Using Space/Time Relationships/a	Recognizing and Using Shapes	1. *IDENTIFY* common two-dimensional shapes. 2. *NAME* common two-dimensional shapes. 3. *IDENTIFY* the common two-dimensional shapes in objects in the environment.
3	Observing/b	Color, Shape, Texture, and Size	1. *IDENTIFY* an object on the basis of color, shape, texture, and size. 2. *NAME* two or more characteristics of an object from the following characteristics: color, shape, size, and texture. 3. *CONSTRUCT* a grouping of objects on the basis of color, shape, texture, and size.
4	Classifying/a	Leaves, Nuts, and Seashells	1. *CONSTRUCT* a classification of objects according to variations in a single characteristic which has been specified by someone else. 2. *CONSTRUCT* a classification of objects according to variations in a single characteristic which he has chosen. 3. *DESCRIBE* the method of classification.
5	Observing/c	Temperature	1. *DISTINGUISH* between two very different temperatures without the aid of a thermometer. 2. *DISTINGUISH* between the temperature in one place and that in another, using a color-coded thermometer. 3. *DISTINGUISH* between the temperature at one time and that at another, using a color-coded thermometer.
6	Using Space/Time Relationships/b	Direction and Movement	1. *IDENTIFY* objects that are moving or not moving. 2. *DEMONSTRATE* movements up, down, forward, back, right, and left. 3. *NAME* the direction in which other children, animals, or objects are moving using the words up, down, forward, back, right, and left.
7	Observing/d	Perception of Taste	1. *DISTINGUISH* between certain food tastes as similar to, or different from, each other. 2. *IDENTIFY* tastes that are sweet, sour, or salty. 3. *NAME* tastes that are sweet, sour, or salty.

NO.	PROCESS	TITLE	OBJECTIVES
8	Measuring/a	Length	1. *DEMONSTRATE* the sorting of objects into sets in which all objects of one set are of equal length. 2. *ORDER* objects by length, from the shortest to the longest. 3. *DEMONSTRATE* a procedure for comparing the length of two objects by using a third object.
9	Using Numbers/a	Sets and Their Members	1. *IDENTIFY* various sets of objects when given the names or characteristics of their members, *IDENTIFY* a member of a set, and *IDENTIFY* a set having only one member. 2. *IDENTIFY* as equivalent two sets which contain the same number of objects, by pairing each object from the first set with a corresponding object from the other set. 3. *IDENTIFY*, given two sets which are not equivalent, the set that has (a) fewer members, or a smaller number of members, or (b) more members, or a greater number of members. 4. *IDENTIFY* the set among three, no two of which are equivalent, that has (a) the fewest members, or the least number of members, or (b) the most members, or the greatest number of members.
10	Using Space/Time Relationships/c	Spacing Arrangements	1. *CONSTRUCT* these shapes: triangle, circle, square, rectangle, and ellipse. 2. *CONSTRUCT* an arrangement of objects in the forms of familiar two-dimensional shapes. 3. *IDENTIFY* and *NAME* the two-dimensional shape formed by a given arrangement of objects.
11	Observing/e	Listening to Whales	1. *IDENTIFY* and *NAME* the louder or softer of two sounds. 2. *IDENTIFY* and *NAME* the longer or shorter of two sounds. 3. *IDENTIFY* and *NAME* the higher or lower (pitch) of two sounds. 4. *IDENTIFY* a sound as being more like one of two dissimilar sounds.
12	Using Space/Time Relationships/d	Three-Dimensional Shapes	1. *IDENTIFY* and *NAME* the following three-dimensional shapes: sphere, cube, cylinder, pyramid, and cone. 2. *IDENTIFY* and *NAME* the two-dimensional shapes that are components of regular three-dimensional shapes.

NO.	PROCESS	TITLE	OBJECTIVES
13	Using Numbers/b	Numerals, Order, and Counting	1. *IDENTIFY* and *NAME* the order position of any object or event in a sequence of five objects or events, using the numerals 1, 2, 3, 4, and 5 and the ordinal names first, second, third, fourth, and fifth. 2. *IDENTIFY* and *NAME* the number of members of a set from 0 to 12 using a written numeral and the number word. 3. *ORDER* sets which have 0 to 12 members. 4. *DESCRIBE* an item in a sequence as being between two other items in the sequence by saying, for example, "The third item is between the second and fourth."
14	Classifying/b	Animals and Familiar Things	1. *CONSTRUCT* a classification of a set of objects into two or more groups depending upon whether the objects can or cannot be used in a stated way. 2. *CONSTRUCT* another classification of the same objects, and *DESCRIBE* the characteristics used to classify the objects.
15	Observing/f	Perception of Odors	1. *DISTINGUISH* between objects that have an odor and those that do not. 2. *IDENTIFY* familiar substances by odor. 3. *IDENTIFY* odors of objects as being similar to or different from odors of other objects.
16	Classifying/c	Living and Nonliving Things Trees in Our Environment	1. *NAME* at least one characteristic of living things. 2. *CONSTRUCT* groupings of living and nonliving things on the basis of observable characteristics.
17	Observing/g	Change	1. *IDENTIFY* a substance as a solid or a liquid. 2. *NAME* the initial and final color of a solid or liquid that changes color. 3. *DESCRIBE* changes in color, shape, size, and phase (changes from solid to liquid and liquid to solid).
18	Observing/h	Using the Senses	1. *DESCRIBE* objects, or changes in objects, after making observations using several of the senses. 2. *IDENTIFY* which sense or senses are used to make an observation, by saying, for example, "I smelled it," "I saw it," and so on.

NO.	PROCESS	TITLE	OBJECTIVES
19	Observing/i	Soils	1. *IDENTIFY* objects, or changes in objects, after making observations using several of the senses. 2. *IDENTIFY* which sense or senses are used to make observations by saying, for example, "I smelled it," "I saw it," and so on.
20	Using Numbers/c	Counting Birds	1. *NAME* points on the number line using the whole numbers $^{-}9$ to 9. 2. *IDENTIFY* and *NAME* any member of the set of whole numbers from $^{-}9$ to 9.
21	Observing/j	Weather	1. *CONSTRUCT* a record of weather conditions on a chart, using symbols. 2. *IDENTIFY* weather conditions and *DISTINGUISH* between conditions from one day to another in comparative terms, such as "hotter or warmer than," "cooler than," "windier than," or "cloudier than," using the data recorded on a weather chart. 3. *NAME* the temperature to the nearest 5 degrees using a Celsius thermometer.
22	Communicating/a	The Same but Different	1. *DESCRIBE* similar characteristics among a group of similar things. 2. *DESCRIBE* different characteristics among a group of similar things. 3. *DISTINGUISH* between a collection of information that is sufficient to identify an object and one that is not. 4. *DESCRIBE* a sufficient number of characteristics of an object to make possible unambiguous identification of the object.
23	Measuring/b	Comparing Volumes	1. *DEMONSTRATE* a way to compare two volumes. 2. *IDENTIFY* which of two containers has the larger volume. 3. *DEMONSTRATE* a way to compare the volumes of two containers by reference to a third container or object. 4. *DEMONSTRATE* a way to measure the volume of a container using a supplied standard of reference.

NO.	PROCESS	TITLE	OBJECTIVES
24	Measuring/c	Metric Lengths	1. *DEMONSTRATE* a way to measure length using a designated standard. 2. *NAME* various units of length in the metric system. 3. *IDENTIFY* an appropriate standard for measuring various lengths. 4. *DEMONSTRATE* a way to measure length using an appropriate standard.
25	Communicating/b	Introduction to Graphing	1. *CONSTRUCT* a bar graph. 2. *NAME* the number of items represented by the bars of a bar graph.
26	Measuring/d	Using a Balance	1. *ORDER* objects of appreciably different weights by lifting them and by comparing them on an equal-arm balance. 2. *STATE THE RULE* that the earth-pull on the heavier of two objects is greater than it is on the lighter object. 3. *DEMONSTRATE* how to compare the weight of small objects by counting the number of arbitrary units, such as cubes, needed to balance the objects on an equal-arm balance. 4. *DESCRIBE* the results of measurements, by saying, for example, "The object weighs the same as six cubes," or "The object weighs more than ten cubes but less than eleven cubes."
27	Communicating/c	Pushes and Pulls	1. *NAME* as a force a push or pull that makes an object move. 2. *DEMONSTRATE* a procedure for comparing sizes of pushes or pulls. 3. *IDENTIFY* the heavier of two similar objects as the one that exerts the greater force when both are moving at the same speed. 4. *DEMONSTRATE* a procedure for measuring and recording changes in the position of an object.
28	Observing/k	Molds and Green Plants	1. *DESCRIBE* characteristics, such as color, texture, shape, odor, and size, of molds and green plants, or parts of green plants. 2. *DESCRIBE* changes in molds and green plants. 3. *IDENTIFY* conditions that produce changes in molds and green plants, or in parts of green plants.

NO.	PROCESS	TITLE	OBJECTIVES
29	Using Space/Time Relationships/e	Shadows	1. *IDENTIFY* a three-dimensional object from its two-dimensional shadows. 2. *IDENTIFY* the two-dimensional shadows of a given three-dimensional object.
30	Using Numbers/d	Addition Through 99	1. *CONSTRUCT* a new set of objects by putting two sets of objects together, and *NAME* the number of members in the new set orally or in writing. The number of members in the two sets combined does not exceed 99, and the members of the two sets are distinct from one another. 2. *NAME* orally the written statement 2 + 3 = 5 as "Two and three are five," "The sum of two and three is five," or "Two and three equals five." And, reversing the process, *CONSTRUCT* the written statement when it is given orally or demonstrated with objects. 3. *NAME* the missing number in a statement like 4 + ? = 7 which has a sum of 9 or less. 4. *DESCRIBE* two-digit numbers as sets of ten and one of the numbers 0 through 9; for example, 57 is 5 sets of ten and 7, or 5 tens and 7. 5. *NAME* the predecessor and successor of each number in any sequence between 0 and 100; for example, 28 is one less than 29, and 32 is one more than 31. 6. *NAME* the sum of any pair of numbers from 0 to 99, the sum of which does not exceed 99. 7. *NAME* the sum of repeated addends of the same number with sums not exceeding 99.
31	Communicating/d	Life Cycles	1. *DESCRIBE* an animal according to several of its characteristics. 2. *DESCRIBE* the characteristics of a young animal as it grows and changes from one stage to another.
32	Classifying/d	A Terrarium	1. *DEMONSTRATE* the separation of living organisms into categories and sub-categories. 2. *CONSTRUCT* a simple classification scheme and *DEMONSTRATE* its use. 3. *DEMONSTRATE* the placing of new organisms in the appropriate categories and sub-categories of a classification scheme.
33	Inferring/a	What's Inside?	1. *DISTINGUISH* between statements that are observations and those that are explanations of observations, and *IDENTIFY* the explanations as inferences. 2. *CONSTRUCT* inferences in terms of likelihood rather than certainty.

NO.	PROCESS	TITLE	OBJECTIVES
34	Measuring/e	About How Far?	1. *CONSTRUCT* estimations of linear dimensions of common objects in terms of centimeters, decimeters, or meters. 2. *IDENTIFY* a known object that is approximately the same length or width as another object.
35	Using Space/Time Relationships/f	Symmetry	1. *IDENTIFY* objects that have line or plane symmetry. 2. *DEMONSTRATE* that some objects can be folded or cut in one or more ways to produce matching halves. 3. *IDENTIFY* and *DESCRIBE* bilateral symmetry.
36	Observing/l	Animal Responses	1. *DESCRIBE* the kinds of locomotion characteristic of animals having various shapes and appendages. 2. *IDENTIFY* an animal's response to an identified stimulus. 3. *DESCRIBE* a stimulus-response situation in the environment of an animal.
37	Measuring/f	Forces	1. *IDENTIFY* balanced forces that act on a stationary object. 2. *STATE A RULE* that a force can cause a coil spring to stretch, and that the greater the force the greater the stretch. 3. *DEMONSTRATE* that two objects have the same or different weights by using a spring scale. 4. *DEMONSTRATE* by using a spring scale that a force is needed to move an object on a horizontal surface.
38	Predicting/a	Using Graphs	1. *CONSTRUCT* a bar graph, given a frequency distribution. 2. *DISTINGUISH* among quantities shown on a bar graph by using terms such as "greater than," "less than," "greatest," and "least." 3. *CONSTRUCT* predictions based on data presented in a bar graph. 4. *CONSTRUCT* a test of predictions based on data presented in a bar graph.
39	Measuring/g	Solids, Liquids, and Gases	1. *DEMONSTRATE* how to measure the volume of a liquid using metric units. 2. *NAME* the volume of a liquid in metric units. 3. *NAME* a substance as being a solid, a liquid, or a gas. 4. *DESCRIBE* the distinguishing characteristics of a solid, a liquid, and a gas.

NO.	PROCESS	TITLE	OBJECTIVES
40	Inferring/b	How Certain Can You Be?	1. *DESCRIBE* new observations needed to test an inference. 2. *IDENTIFY* observations that support an inference. 3. *DISTINGUISH* between an inference that accounts for all of the observations and one that does not.
41	Measuring/h	Temperature and Thermometers	1. *DEMONSTRATE* how to use a thermometer to measure the temperature of a gas or liquid. 2. *NAME* the temperature of a given gas or liquid to the nearest degree Celsius. 3. *DEMONSTRATE* how to use a thermometer to measure changes in temperature. 4. *NAME* observed changes in temperature in degrees Celsius.
42	Classifying/e	Sorting Mixtures	1. *DEMONSTRATE* a specified method for classifying components in a given mixture according to the size of the particles of the components. 2. *ORDER* the components of a mixture according to the size of the particles of the components. 3. *ORDER* the components of a mixture according to the amount (volume or weight) of each component.
43	Communicating/e	A Plant Part That Grows	1. *DESCRIBE* vegetative growth qualitatively. 2. *DESCRIBE* the techniques used to produce growth from plant parts other than seeds, in terms precise enough that other people will be able to follow the procedure.
44	Predicting/b	Surveying Opinion	1. *DESCRIBE* a method for collecting and organizing simple data. 2. *CONSTRUCT* a bar graph to represent a given collection of data. 3. *CONSTRUCT* a prediction based on an examination of the data presented in a graph or collection of graphs.
45	Using Space/Time Relationships/g	Lines, Curves, and Surfaces	1. *IDENTIFY* and *NAME* straight and curved paths on a plane surface. 2. *CONSTRUCT* curved paths on the surface of a sphere, a cone, and a cylinder and straight paths on a cone and cylinder. 3. *DEMONSTRATE* how to determine whether a surface is a plane surface. 4. *DISTINGUISH* linear from non-linear motion. 5. *IDENTIFY* and *NAME* circular motion.

NO.	PROCESS	TITLE	OBJECTIVES
46	Inferring/c	Observations and Inferences	1. *DISTINGUISH* between observations and inferences. 2. *CONSTRUCT* one or more inferences from an observation or a set of observations. 3. *DEMONSTRATE* that inferences may need to be revised on the basis of additional observations.
47	Communicating/f	Scale Drawings	1. *DISTINGUISH* between representations of objects that are life-size and those that are not. 2. *DESCRIBE* the relationship between the actual size of an object and its representation when the scale is given. 3. *DEMONSTRATE* a procedure for drawing an object to a given scale.
	Communicating/g	A Tree Diary	1. *IDENTIFY* changes in a selected tree from observations made over a period of several months. 2. *CONSTRUCT* inferences about changes observed. 3. *DESCRIBE* the tree as a whole and with reference to its parts, including changes in the tree and its parts over several months.
48	Predicting/c	The Bouncing Ball	1. *CONSTRUCT* a bar graph to show the relationship between two variables. 2. *CONSTRUCT* predictions by interpolating on a graph. 3. *DEMONSTRATE* a test of a constructed prediction.
49	Measuring/i	Drop by Drop	1. *DEMONSTRATE* that a drop of liquid can be used as a unit of measure for finding the volumes of liquids. 2. *DEMONSTRATE* that drops of different liquids formed by droppers with openings of the same size may have different volumes. 3. *DEMONSTRATE* that drops of the same liquid formed by droppers with openings of different sizes have different volumes.
50	Predicting/d	The Clean-up Campaign	1. *CONSTRUCT* a bar graph showing the amount of litter, or solid waste, collected over a period of time. 2. *CONSTRUCT* a prediction based on data presented in a bar graph. 3. *CONSTRUCT* a test of a prediction based on data presented in a bar graph.

NO.	PROCESS	TITLE	OBJECTIVES
51	Using Space/Time Relationships/h	Rates of Change	1. *DEMONSTRATE* how to find the rate of change in a given amount of substance when the rate is measured in units of weight or distance or volume, and time. 2. *APPLY A RULE* to find the rate of change in position, or speed, of a moving object. 3. *DISTINGUISH* among objects according to their speeds, using terms such as "faster than" and "slower than." 4. *NAME* the whole number quotient for any division sentence, given a dividend less than 100 and a divisor less than 10.
52	Inferring/d	Plants Transpire	1. *CONSTRUCT* inferences about evaporation under various conditions. 2. *CONSTRUCT* inferences about condensation under various conditions. 3. *CONSTRUCT* inferences about water loss based on observation of plants. 4. *DESCRIBE* observations that can be used to test an inference. 5. *CONSTRUCT* a prediction from a line graph about water loss from plants.
53	Predicting/e	The Suffocating Candle	1. *CONSTRUCT* predictions based on a series of observations that reveal a pattern. 2. *CONSTRUCT* a revision of a prediction on the basis of additional information.
54	Measuring/j	Static and Moving Objects	1. *DESCRIBE* forces acting on nonmoving objects. 2. *DESCRIBE* forces acting on moving objects. 3. *CONSTRUCT* diagrams showing the forces acting on moving and nonmoving objects.
55	Observing/m	Sprouting Seeds	1. *IDENTIFY* changes in growing plants from day to day. 2. *CONSTRUCT* a chart on which to show growth of plants from seeds.
	Observing/n	Magnetic Poles	1. *IDENTIFY* the north-seeking and south-seeking poles of a magnet using the known poles of another magnet. 2. *CONSTRUCT* an electromagnet. 3. *DEMONSTRATE* that a magnet has a magnetic field.
56	Classifying/f	Punch Cards	1. *CONSTRUCT* a classification of objects into subsets. 2. *CONSTRUCT* a punch-card system to record simple data. 3. *DEMONSTRATE* the use of a punch-card system.

NO.	PROCESS	TITLE	OBJECTIVES
57	Communicating/h	Position and Shape	1. *IDENTIFY* and *NAME* positions on a map. 2. *CONSTRUCT* a map of an area to scale. 3. *NAME* the ordered number pair that locates a position on a map or grid. 4. *IDENTIFY* the position of an ordered number pair on a map or grid. 5. *CONSTRUCT* drawings of regular, three-dimensional shapes and of objects that exhibit these shapes.
58	Inferring/e	Liquids and Tissues	1. *DESCRIBE* observations of the effect of a liquid on plant or animal material. 2. *DISTINGUISH* between observations of and inferences about the effect of a liquid on plant or animal material. 3. *CONSTRUCT* an inference to explain the effect of a liquid on plant or animal material.
59	Using Numbers/e	Metersticks, Money, and Decimals	1. *DEMONSTRATE* how to write decimal notation for parts of a dollar. 2. *CONSTRUCT* points on a number line, using decimal notation for tenths and hundredths. 3. *DEMONSTRATE* how to use and write measurements to the nearest tenth of a unit using meters, decimeters, and centimeters.
60	Using Space/Time Relationships/i	Relative Position and Motion	1. *DESCRIBE* positions and appearances of objects relative to himself and to other observers. 2. *DESCRIBE* changes in positions of objects relative to himself and to other observers.
61	Inferring/f	Circuit Boards	1. *CONSTRUCT* a complete electric circuit consisting of a dry cell, a lamp, and two wires. 2. *CONSTRUCT* connection patterns based on inferences about hidden circuits. 3. *DESCRIBE* the expected outcomes of tests based upon inferred connection patterns.
62	Controlling Variables/a	Climbing Liquids	1. *IDENTIFY* variables which might affect the rate of upward movement of liquids through materials. 2. *IDENTIFY* the variable that is manipulated in an investigation of the upward movement of liquids through materials. 3. *IDENTIFY* the variables that are held constant in an investigation of the upward movement of liquids through materials. 4. *DEMONSTRATE* that a liquid moves upward faster in some materials than it does in others. 5. *DEMONSTRATE* that, in a given material, different liquids move upward at different rates.

NO.	PROCESS	TITLE	OBJECTIVES
63	Interpreting Data/a	Maze Behavior	1. *DESCRIBE* the changes in an animal's performance of a task that result from repeated trials or practice. 2. *CONSTRUCT* a graph showing how an animal's performance depends on the number of trials or the amount of practice. 3. *IDENTIFY* the data that support the statement that the time required to perform a task will generally be shortened after a number of trials.
64	Defining Operationally/a	Cells, Lamps, and Switches	1. *IDENTIFY* a simple electric circuit or a part of an electric circuit on the basis of an operational definition. 2. *DISTINGUISH* between an operational and a nonoperational definition of an object, a situation, or an event related to simple electric circuits.
65	Interpreting Data/b	Minerals in Rocks	1. *DISTINGUISH* between minerals having metallic and nonmetallic luster. 2. *DEMONSTRATE* how to compare the hardness of minerals by using a scratch test with copper and with glass. 3. *IDENTIFY* classification categories for a given mineral from observations of its hardness, luster, streak, and color. 4. *NAME* an unknown mineral using a punch-card information storage system that is provided. 5. *IDENTIFY* evidence concerning the origin of common sedimentary rocks.
66	Controlling Variables/b	Learning and Forgetting	1. *IDENTIFY* and *NAME* the manipulated variable and the responding variable in an investigation of a question about learning. 2. *IDENTIFY* and *NAME* the variables held constant in an investigation of a question about learning. 3. *CONSTRUCT* a graph from data obtained in an investigation about learning. 4. *IDENTIFY* data presented on a graph or table that provide an answer to the question being investigated.
67	Interpreting Data/c	Identifying Materials	1. *CONSTRUCT* a record of observed chemical and physical changes, using a table or punch cards. 2. *NAME* unknown materials by comparing observations of chemical or physical changes in these materials with previously recorded data. 3. *NAME* the unknown components of mixtures by comparing observations of physical and chemical properties with previously recorded data.

NO.	PROCESS	TITLE	OBJECTIVES
68	Interpreting Data/d	Field of Vision	1. *DESCRIBE* how the field of vision, the area, depends on the distance of the field from the viewer. 2. *CONSTRUCT* a graph to show the relationship between the field of vision and the distance of the field from the viewer. 3. *CONSTRUCT* predictions from a graph of the field of vision and the distance of the field from the viewer.
69	Defining Operationally/b	Magnification	1. *CONSTRUCT* operational definitions of small objects based on observations made with a hand lens or microscope. 2. *STATE A RULE* for determining the amount of magnification and actual size of objects that have been magnified.
70	Formulating Hypotheses/a	Conductors and Non-conductors	1. *DISTINGUISH* between statements that are hypotheses and statements that are not. 2. *DISTINGUISH* between observations which support a stated hypothesis and those which do not. 3. *CONSTRUCT* a hypothesis from a set of observations. 4. *CONSTRUCT* a prediction based on a hypothesis.
71	Controlling Variables/c	Seeds and Soap	1. *IDENTIFY* the manipulated variable, the responding variable, and the variables held constant in an investigation of germination in detergent or other solutions. 2. *IDENTIFY* one or more variables not held constant in an investigation of seed germination in detergent or other solutions. 3. *DESCRIBE* a way to modify an investigation so that a previously uncontrolled variable is held constant.
72	Controlling Variables/d	Heart Rate	1. *NAME* variables held constant and those not held constant in an investigation of human heart rate. 2. *CONSTRUCT* one or more hypotheses about the effect of one manipulated variable on a responding variable in an investigation of human heart rate, given data in a table or graph. 3. *CONSTRUCT* and *DEMONSTRATE* a test to show the effect of one manipulated variable on a responding variable in an investigation of human heart rate. 4. *IDENTIFY* data about human pulse rates and *DESCRIBE* how the data support or do not support the hypothesis.

NO.	PROCESS	TITLE	OBJECTIVES
73	Formulating Hypotheses/b	Solutions	1. *CONSTRUCT* a hypothesis to explain observations made or data collected. 2. *DEMONSTRATE* methods to manipulate and hold constant variables in a test of a hypothesis. 3. *IDENTIFY* data that support or do not support a hypothesis.
74	Defining Operationally/c	Biotic Communities	1. *CONSTRUCT* an operational definition of a member of a biotic community, such as a producer, consumer, or decomposer. 2. *IDENTIFY* a member of a biotic community from an operational definition.
75	Interpreting Data/e	Decimals, Graphs, and Pendulums	1. *NAME* and *IDENTIFY* positions on the number line, using tenths in decimal notation. 2. *APPLY A RULE* for measuring length to the nearest 0.1 centimeter, volume to the nearest 0.1 milliliter, time to the nearest 0.1 second, and weight to the nearest 0.1 arbitrary unit. 3. *CONSTRUCT* a graph, using number pairs expressed in tenths and/or large numbers. 4. *CONSTRUCT* interpretations of data shown in a graph.
76	Interpreting Data/f	Limited Earth	1. *DEMONSTRATE* a procedure for estimating a population of an area using a random sampling technique. 2. *IDENTIFY* and *NAME* variables in the environment that affect the size of an animal or plant population. 3. *CONSTRUCT* inferences to explain change in a population size over a given time.
77	Controlling Variables/e	Chemical Reactions	1. *IDENTIFY* variables that may affect the responding variable in an investigation of a chemical reaction. 2. *IDENTIFY* the manipulated variable, the responding variable, and the variables that are held constant in an investigation of a chemical reaction. 3. *DEMONSTRATE* procedures to hold constant and to manipulate variables in an investigation of a chemical reaction.
78	Formulating Hypotheses/c	Levers	1. *CONSTRUCT* a hypothesis about levers in balance. 2. *CONSTRUCT* and *DEMONSTRATE* a test of a hypothesis about levers in balance. 3. *IDENTIFY* data that support or do not support a hypothesis about levers in balance.
79	Formulating Hypotheses/d	Animal Behavior	1. *IDENTIFY* or *CONSTRUCT* inferences or hypotheses about animal behavior based on observations. 2. *CONSTRUCT* and *DEMONSTRATE* tests of inferences or hypotheses about animal behavior. 3. *DESCRIBE* how data support or do not support a hypothesis about animal behavior.

NO.	PROCESS	TITLE	OBJECTIVES
80	Defining Operationally/d	Inertia and Mass	1. *CONSTRUCT* an operational definition of inertia. 2. *DEMONSTRATE* the use of an operational definition to measure mass in grams, using an equal-arm balance. 3. *CONSTRUCT* an alternative operational definition of mass in grams, using a vibrator.
81	Defining Operationally/e	Analysis of Mixtures	1. *DISTINGUISH* between mixtures that are solutions and those that are not, using an operational definition. 2. *DEMONSTRATE* a procedure for separating a mixture into its components, using an operational definition. 3. *DEMONSTRATE* a procedure for determining the mass of each component of a mixture. 4. *IDENTIFY* data that support and do not support a hypothesis about the masses of components of a mixture.
82	Controlling Variables/f	Force and Acceleration	1. *IDENTIFY* the manipulated variable, the responding variable, and variables held constant in an investigation of the relationship between force and acceleration. 2. *IDENTIFY* the manipulated variable, the responding variable, and variables held constant in an investigation of the relationship between mass and acceleration. 3. *APPLY A RULE* to measure an unknown force, and express the measurement in the standard metric unit of force, the newton. 4. *CONSTRUCT* a force diagram to illustrate that only balanced forces are acting on a body at rest. 5. *CONSTRUCT* a force diagram to illustrate that an unbalanced force is acting on a body that is changing speed.
83	Formulating Hypotheses/e	Chances Are	1. *CONSTRUCT* more than one hypothesis from data collected in a study of inherited characteristics. 2. *IDENTIFY* data that support and do not support a hypothesis. 3. *CONSTRUCT* a probability sentence from data collected in a table or shown in a matrix. 4. *IDENTIFY* all possible outcomes of an event in which the number of outcomes can be counted, and *IDENTIFY* which of these outcomes are favorable and which are not favorable. 5. *NAME* the probability of an event by identifying the favorable outcomes from among the possible outcomes.

NO.	PROCESS	TITLE	OBJECTIVES
84	Interpreting Data/g	Angles	1. *DEMONSTRATE* how to measure angles using a protractor. 2. *IDENTIFY* angles of incidence and reflection or refraction 3. *DEMONSTRATE* that the angle of incidence is equal to the angle of reflection.
85	Interpreting Data/h	Contour Maps	1. *IDENTIFY* and *NAME* contour lines and elevations from a contour map. 2. *CONSTRUCT* a two-dimensional contour map of a three-dimensional object, or a three-dimensional object from a two-dimensional map. 3. *DISTINGUISH* between areas of high slope and low slope on a contour map. 4. *CONSTRUCT* a cross-sectional profile from a contour map.
86	Interpreting Data/i	Earth's Magnetism	1. *NAME* the poles of a magnet by noting a pattern of compass direction lines around the magnet. 2. *CONSTRUCT* one or more inferences to account for patterns of compass directions on the surface of Earth. 3. *DEMONSTRATE* how to determine the direction of true north, given the magnetic declination and the direction of magnetic north at a given location.
87	Interpreting Data/j	Wheel Speeds	1. *DESCRIBE* a method for determining the relationship between circumference and diameter of a circle. 2. *DEMONSTRATE* a procedure for finding angular speed of a rolling object in rotations per minute, given the number of rotations made in a fraction of a minute. 3. *APPLY A RULE* for finding the linear speed of a rolling object given its angular speed and its circumference.
88	Defining Operationally/f	Environmental Protection	1. *CONSTRUCT* an operational definition of a consumer, such as carnivore, omnivore, or herbivore. 2. *IDENTIFY* a consumer from an operational definition. 3. *CONSTRUCT* an operational definition of a term related to something undesirable in the environment.

NO.	PROCESS	TITLE	OBJECTIVES
89	Defining Operationally/g	Plant Parts	1. *DEMONSTRATE* the use of an operational definition to identify a plant part. 2. *CONSTRUCT* an operational definition of a plant part. 3. *CONSTRUCT* an alternative operational definition of a plant part. 4. *CONSTRUCT* an operational definition related to growth of a plant.
90	Formulating Hypotheses/f	Streams and Slopes	1. *CONSTRUCT* hypotheses consistent with data regarding stream flow. 2. *DISTINGUISH* between observations that support a hypothesis and those that do not. 3. *CONSTRUCT* predictions about erosion and deposition based on a hypothesis that relates these phenomena to stream flow.
91	Defining Operationally/h	Flowers	1. *CONSTRUCT* operational definitions of parts of flowering plants. 2. *IDENTIFY* parts of flowering plants using operational definitions.
92	Formulating Hypotheses/g	Three Gases	1. *CONSTRUCT* an operational definition of a gas based on data collected by the student. 2. *IDENTIFY* a gas using an operational definition. 3. *CONSTRUCT* a revision of a hypothesis based on additional observations.
93	Defining Operationally/i	Temperature and Heat	1. *CONSTRUCT* operational definitions of temperature and heat. 2. *CONSTRUCT* an alternative operational definition of heat.
94	Controlling Variables/g	Small Water Animals	1. *CONSTRUCT* and *DEMONSTRATE* a test of an effect of a manipulated variable on the behavior of a responding variable. 2. *DESCRIBE* how data support or do not support a hypothesis that has been constructed.
95	Interpreting Data/k	Mars Photos	1. *DESCRIBE* a location on a map using longitude and latitude. 2. *DEMONSTRATE* a procedure for making indirect measurements of features on the surface of Mars, given the information necessary to determine the scale of a photograph. 3. *DESCRIBE* the three-dimensional shapes of objects pictured in photographs of Mars on the basis of inferences about the direction of illumination.

NO.	PROCESS	TITLE	OBJECTIVES
96	Experimenting/a	Pressure-Volume Relationships	1. *NAME* each word or phrase in need of an operational definition and *CONSTRUCT* the needed operational definitions, given a hypothesis or a question to be tested. 2. *NAME* the responding variable and *DEMONSTRATE* how the responding variable is to be measured, given a hypothesis or a question to be tested.
97	Experimenting/b	Optical Illusions	1. *NAME* the responding variable and *DESCRIBE* how it is to be measured, given a hypothesis to be tested. 2. *NAME* the variable to be manipulated and *DESCRIBE* how it is to be manipulated, given a hypothesis to be tested.
98	Experimenting/c	Eye Power	1. *NAME* the variable to be manipulated, and *DEMONSTRATE* how it is to be manipulated, given the statement of a hypothesis. 2. *NAME* the variables to be held constant, and *DEMONSTRATE* how each is to be held constant, given the statement of a hypothesis.
99	Experimenting/d	Fermentation	1. *NAME* the variable to be manipulated, and *DEMONSTRATE* how it is to be manipulated, given a statement of a hypothesis or a question to be tested. 2. *DESCRIBE* how the data support or do not support a hypothesis, and *CONSTRUCT* a revision of a hypothesis if the data do not support the original one, given a statement of a hypothesis and a set of data in narrative, graphical, or tabular form.
100	Experimenting/e	Plant Nutrition	1. *CONSTRUCT* a test of a hypothesis concerning plant growth and *DEMONSTRATE* the test. 2. *NAME* the variables to be held constant, given a statement of a hypothesis to be tested. 3. *DESCRIBE* how data support or do not support a hypothesis and *CONSTRUCT* a revision of the hypothesis consistent with the data.
101	Experimenting/f	Mental Blocks	1. *CONSTRUCT* a hypothesis, and in a test of the hypothesis, *CONSTRUCT* all needed operational definitions, and *NAME* and *DEMONSTRATE* how to measure the responding variable, how to vary the manipulated variable, and how to hold other variables constant.
102	Experimenting/g	Plants in Light	1. *CONSTRUCT* a question or hypothesis, given data in narrative, graphical, or tabular form, and in a test of the question or hypothesis *CONSTRUCT* all needed operational definitions; *NAME* and *DEMONSTRATE* how to measure the responding variable, how to manipulate one or more variables, and how to hold other variables constant.

NO.	PROCESS	TITLE	OBJECTIVES
103	Experimenting/h	Density	1. *CONSTRUCT* a hypothesis to be investigated. 2. *CONSTRUCT* and *DEMONSTRATE* a test of the stated hypothesis. 3. *DESCRIBE* the data collected. 4. *DESCRIBE* how the data support or do not support the hypothesis. 5. *CONSTRUCT* a revised hypothesis if the data do not support the original hypothesis.
104	Experimenting/i	Viscosity	1. *CONSTRUCT* a hypothesis to be investigated. 2. *CONSTRUCT* and *DEMONSTRATE* a test of the stated hypothesis. 3. *DESCRIBE* the data collected. 4. *DESCRIBE* how the data support or do not support the hypothesis. 5. *CONSTRUCT* a revised hypothesis if the data do not support the original hypothesis.
105	Experimenting/j	Membranes	1. *CONSTRUCT* a hypothesis to be investigated. 2. *CONSTRUCT* and *DEMONSTRATE* a test of the stated hypothesis. 3. *DESCRIBE* the data collected. 4. *DESCRIBE* how the data support or do not support the hypothesis. 5. *CONSTRUCT* a revised hypothesis if the data do not support the original hypothesis.

MATERIALS

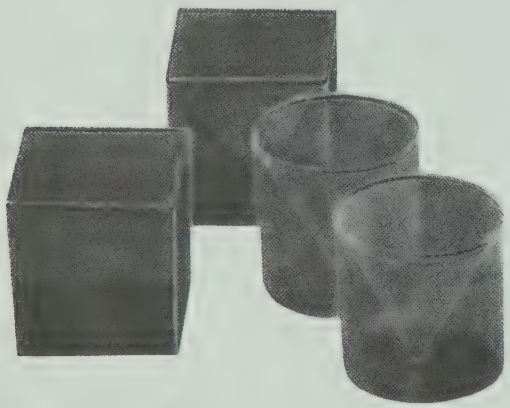
Many activities in SCIENCE . . . A PROCESS APPROACH II require simple, readily available materials such as string, washers, jars, and candles. Specially designed equipment is also used. Equal-arm balances, spring scales, dry cell holders, switches and other apparatus have been designed and constructed just for this program.

All of the specially designed equipment, the materials prepared for the auto-instructional and peer-teaching activities, and many of the common materials are packaged in the module boxes supplied by Ginn and Company. The location of each item is indicated in parentheses in the materials list of the module *Instruction Booklet.* Materials without a module number in parentheses must be obtained locally.

Some equipment in the module boxes can be reused year after year. Other materials are used up and must be resupplied each year. These are shown in italics on the box label. Materials that must be replaced can be obtained from Ginn and Company in grade level kits or by individual module.

Each module contains enough equipment and supplies for a class of thirty children. Ideally, each teacher should have available all of the modules to be taught during the year. This is the best way to keep track of equipment, such as balances, that may be used in more than one module. However, it may be necessary for two or three teachers to share modules. To do this effectively, it is necessary to have extra sets of expendable materials for each teacher.

Remember that this is a "hands-on" program! Children learn skills by manipulating materials. There must be sufficient supplies for each class so that the children can work individually or in small groups.



Clear Plastic Shapes

Equal-Arm Balance

THE CLASSROOM LABORATORY

The laboratory for this program is the classroom and the out-of-doors. No special laboratory furniture is required. Often exercises require the children to work on the floor. In many exercises the children work alone or in small groups at their desks. If the activity calls for a level surface, and the desks in your room are not level, you will need to find a way to level them. (A book usually works well.)

Whenever the children are doing science activities in small groups, in the classroom or on the playground, *they will tend to be noisy!* When the program is taught properly, noise in the classroom is inevitable and is a healthy outcome. Don't stamp out children's enthusiasm by too rigid instruction.

Many exercises in the program require the children to use water. If you have no sink, you will need to bring containers of water into your room and provide an empty container for waste disposal. Whenever children are working with liquids, spills will likely occur. Some teachers have children use trays from the lunchroom to catch spills. Others use newspaper.

Not all materials that are required in the *Instruction Booklet* are supplied. Attention to these items before the lessons are taught will greatly improve the effectiveness of this program. If the modules are shared by several teachers of a grade level, materials for the entire grade level can be obtained locally at the same time. Many of these items can be obtained by making a master from the list and sending it home to parents. Instructions accompanying the list should instruct parents as to what can be sent to school with their children. Living or perishable items can be acquired easily and inexpensively locally.

This program should provide maximum adaptability. It can be used in open or traditional classrooms, with large or small groups, with a high degree of individualization or none at all, in graded situations or non-graded.

The *Instruction Booklets* for each module provide a plan to help you in the classroom. You should, however, adapt the plan and personalize it to fit your teaching style. The booklets are designed to direct, facilitate, and ease the way for maximum skill attainment. *READ EVERYTHING BEFORE DOING ANYTHING!*

The need for "planning ahead" is obvious. You will experience a high degree of satisfaction and success if you keep in mind these three steps:

1) Where am I going? What do I want to achieve with my children?
2) How am I going to get there? What vehicle(s) and materials will I need? How much do I need to get?
3) What device will I choose to measure the children's progress?

THE BASIC PROCESSES

Observing

Observing means using the senses to obtain information or data about objects and events. Observing is the most basic process of science. Casual observations spark almost every inquiry we make about our environment. Organized observations form the basis for a structured investigation. Observations lead to the making of inferences or hypotheses, which can be tested by further observations. In this program, fourteen modules are devoted to the process of observing.

CAUTION: Care is needed when using *taste* as an information input. Remember that some things are poisonous or harmful. Always caution the children NOT to taste unknown objects!

Using Space/Time Relationships

All objects occupy points in space at a given point in time. The description of spatial relationships and their change with time are the skills developed in the process *using space/time relationships.* The activities in this process can be grouped into five categories: shapes, direction and spatial arrangement, motion and speed, symmetry, and rate of change.

Classifying

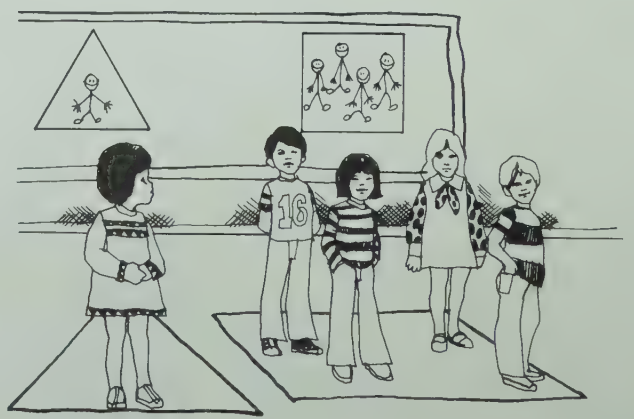
Classifying is the process scientists use to impose order on collections of objects or events. Classification schemes are used in science, as well as in other areas, to identify objects or events and to show similarities, differences, and interrelationships.

In SCIENCE ... A PROCESS APPROACH II, students begin with simple classifications of physical and biological systems. They progress to multi-stage classifications, their coding and tabulations.

Using Numbers

We need numbers to manipulate measurements, to order objects, and to classify objects. The amount of time spent on the exercises devoted to using numbers should depend largely on the mathematics program in the school. It is important for the children to realize that the ability to use numbers is a basic and fundamental process of science.

The sequence begins with identifying sets and their numbers, and progresses through ordering, counting, adding, multiplying, dividing, finding averages, using decimals, and powers of ten. The number line is used in the early exercises as a graphic way of teaching positive and negative numbers.



Measuring

Measuring is the way we quantify our observations. Skill in measuring requires not only the ability to use measuring instruments properly, but also the ability to carry out calculations with these instruments. The process involves judgment about which instrument to use, and when approximate rather than precise measurements are acceptable.

The metric system of measurement is used exclusively in SCIENCE ... A PROCESS APPROACH II. Students learn to measure length, area, volume, mass, temperature, force, and speed as this process is developed through the program.

Communicating

Clear, precise communication is fundamental to all scientific work, as indeed it is essential to all human endeavors. Scientists communicate with oral and written words, diagrams, maps, graphs, mathematical equations, and various kinds of visual demonstrations.

While skills in communicating are taught only through Module 60, graphing is used throughout the program. To reinforce and extend skills in graph making, four auto-instructional booklets are provided throughout the program for student use. These booklets are called *Making a Line Graph 1, 2, 3,* and *4,* respectively.

Predicting

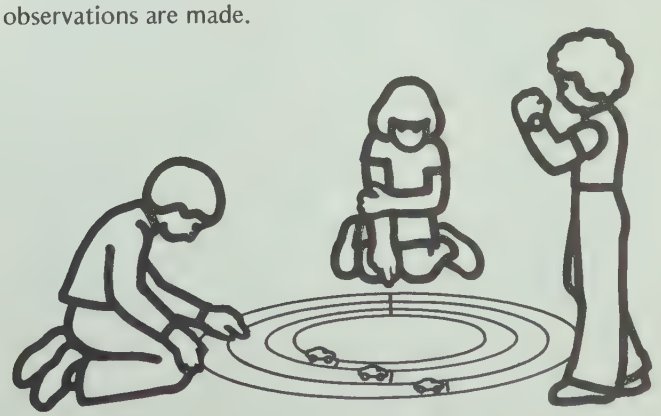
A prediction is a specific forecast of what a future observation will be. Predictions are based on observations, measurements, and inferences about relationships between observed variables. A prediction that is not based on observation is only a guess. Accurate predictions can result from careful observation and precise measurement.

Five modules are devoted to the *predicting* process. At first children make predictions from very simple sets of data and from graphs. Later on, they make predictions on the basis of opinion surveys.

Inferring

Inferring is using logic to draw conclusions from what we observe. Nothing is more fundamental to clear thinking than the ability to distinguish between an observation and an inference. An observation is an experience that is obtained through one of the senses. An inference is an explanation of an observation. The thought involved in making an inference can occur in a fraction of a second, and is often strongly conditioned by past experiences.

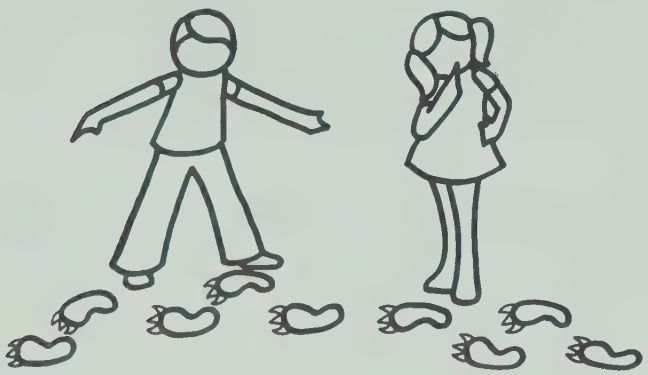
The module that introduces *inferring* has the children make observations about packaged objects. The children cannot see, touch, smell, or taste the objects. They shake the boxes, smell them, and then infer what is inside the packages. The children realize that there can be more than one inference made to explain an observation. They also learn that inferences may have to be revised when new observations are made.



Controlling Variables

Controlling variables means managing the conditions of an investigation. A variable is an object or quantity that can change. In an investigation, best results are achieved when the variables can be identified and carefully controlled. Thus the scientist changes, or manipulates, one variable in a systematic way. While doing this, he or she watches and measures corresponding changes in another, or responding, variable. At the same time the scientist holds constant all the other variables.

Students develop skills in identifying variables and in describing how they have controlled variables in a given investigation.



Interpreting Data

We are constantly interpreting data when we read weather maps, watch the news on television, and look at photographs in newspapers or magazines. The process of interpreting data involves making predictions, inferences, and hypotheses from the data collected in an investigation.

Students approach this process with previous experience in making observations, classifications, and measurements. They make records of their investigations and predict, infer, and interpret from the data collected.

Formulating Hypotheses

A hypothesis is a generalization that includes all objects or events of the same class. Hypotheses may be formulated from observations or inferences. For example, you may observe that a cube of sugar dissolves faster in hot water than in cold water. From this observation, you might formulate the hypothesis that all substances soluble in water dissolve faster in hot water than in cold water. A hypothesis may be generalized from an inference in the following example: If you invert a glass jar over a burning candle, the candle will go out in a short while. You might infer from this observation that the candle went out because all of the oxygen in the jar was used up. You might then formulate the hypothesis that burning candles covered with glass jars go out when all of the oxygen in the jar is used up.

Children are introduced to this process by first learning to distinguish between hypotheses and observations. They then learn to distinguish hypotheses from inferences and predictions. As the process skills are developed, the students construct hypotheses and test them.

Defining Operationally

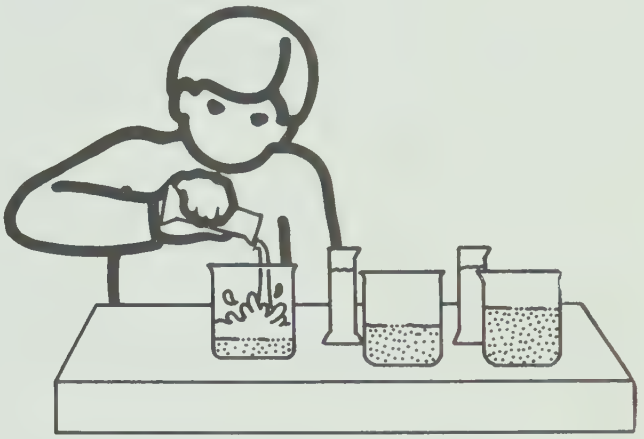
In this process students define terms in the context of their own experiences. That is, the children *work* with a definition instead of memorizing it. A definition that limits the number of things to be considered and is experiential is more useful than a definition that encompasses all possible variations that might be encountered. Thus, in the physical sciences, an operational definition is based on what is done and what is observed. In the biological sciences, an operational definition is descriptive.

Students begin this process by learning the difference between those definitions that are operational and those that are not. For instance, one operational definition for oxygen is that it makes a glowing stick burn more brightly. A nonoperational definition is that oxygen is the eighth atomic element. The students develop skills in constructing definitions in problems that are new to them.

Experimenting

Experimenting is the process that encompasses all of the basic and integrated processes. An exercise in experimenting usually begins with observations that suggest questions to be answered. Sometimes the student formulates a hypothesis from the question or questions. The succeeding steps involve identifying the variables to be controlled, making operational definitions, constructing a test, carrying out the test, collecting and interpreting data, and sometimes modifying the hypothesis that was being tested.

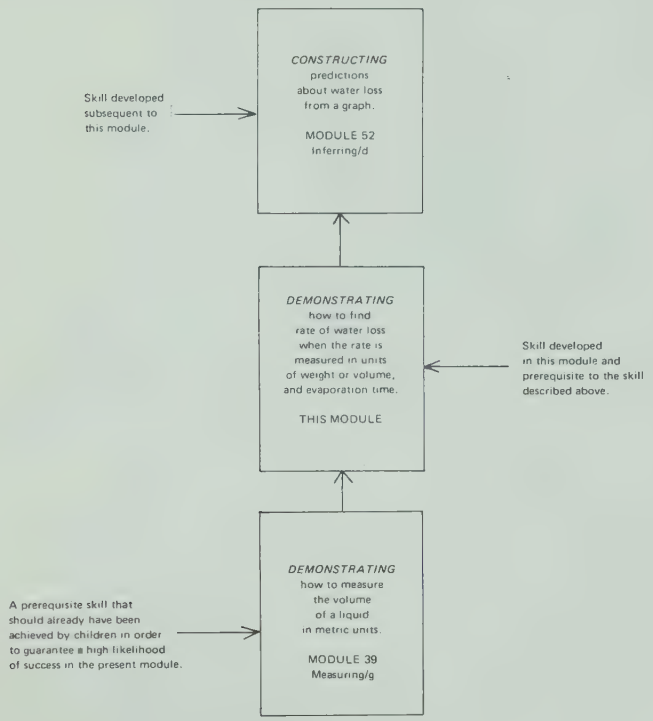
The last ten modules of SCIENCE . . . A PROCESS APPROACH II are devoted to experimenting. These modules are taught after all of the other integrated processes have been introduced and practiced.



MODULE SEQUENCING

Numerical Sequence

One convenient order for using the modules is the numerical sequence with which they are coded. If that order is followed, children will have the opportunity to develop skills in a sequence in which success is highly probable. But this is only *one way* to use the program. The modules need not be taught in numerical sequence as long as the children know the prerequisites before a module is begun. The *Sequence* charts in the *Instruction Booklets* for each module provide a most accurate means for planning a sequence for children. Another resource for identifying a good learning sequence is the *Planning Chart.*


Skill developed subsequent to this module.
CONSTRUCTING predictions about water loss from a graph.
MODULE 52 Inferring/d
DEMONSTRATING how to find rate of water loss when the rate is measured in units of weight or volume, and evaporation time.
THIS MODULE
Skill developed in this module and prerequisite to the skill described above.
A prerequisite skill that should already have been achieved by children in order to guarantee a high likelihood of success in the present module.
DEMONSTRATING how to measure the volume of a liquid in metric units.
MODULE 39 Measuring/g

Stages

The *Planning Chart* is divided into a series of columns called *stages.* Each stage represents a level of learning difficulty. The modules within a stage can be taught in any order. After the children have completed the modules at a given stage, they can proceed to any of the modules at the next stage.

Clusters

The modules are also grouped into *clusters,* which are identified by color on the *Planning Chart.* The modules within a cluster are related by process skills and by objective. Within a cluster, instruction should proceed from stage to stage. Modules at one stage should be completed before going to the next advanced stage. Within a particular grade level, the clusters are independent of each other. An effective learning sequence can be organized around the clusters.

Note that on the *Planning Chart* there are one or more clusters on a red background. These are called *key clusters,* because the skills developed in these modules are critical to success in the modules that follow. The following modules are included in the key clusters:

Modules 1, 2, 3, and 4
Modules 23, 24, 25, 26, and 27
Modules 38 and 44
Modules 32, 39, and 42
Modules 46, 47A, 48, and 49 (These modules should be used before any modules numbered above 50. Use them in any order.)
Modules 61, 64, and 70 (These modules are prerequisite to most that follow.)
Modules 62, 63, and 66 (These modules are prerequisite to many that follow.)
Module 77
Modules 78, 80, 81, and 82

For Students Without Prerequisite Skills

Frequently individual children or entire schools are introduced to SCIENCE . . . A PROCESS APPROACH II without the opportunity to acquire the skills developed in the lower levels of the program. Individual children are often able to pick up these skills as they work in groups with more experienced youngsters. For groups, delayed entry into the program can be accomplished smoothly by backing up for remedial instruction in essential areas.

Certain modules have been designated as *Delayed Entry Back-Up Topics,* or DEBUT modules. These modules were selected because they are the simplest and most effective ones. Teachers using DEBUT modules should be sensitive to the fact that while the ideas in the modules are essential, the teaching approach may have to be altered for older children. For example, the basic ideas in Module 24, *Metric Lengths,* have been used with first graders as well as with teachers in inservice training, but the teaching approaches have been different.

Delayed Entry Back-Up Topics represent key aspects of each of the processes. For example, Module 61 has as its prerequisites the skills contained in Modules 52 and 58. However, Module 46 was designated as the DEBUT module because it can be completed more quickly and with less expense than the others. After completing Module 46, a student with no previous background in the program should be able to perform reasonably well with Module 61. The chart below shows the DEBUT modules at each grade level.

Grade	*Modules*	*DEBUT Modules*
1	16-30	2, 12
2	31-45	18, 24, 25, 26, 27
3	46-60	24, 33, 38, 39
4	61-75	24 and/or 59, 39, 46, 47a, 53
5	76-90	39, 46, 59, 61, 62, 63, 64, 70, 75
6	91-105	None. The first five modules of this level review the integrated processes.

At levels 4 and 5 it may be impossible to complete all modules after doing the DEBUT modules. Care should therefore be taken in selecting additional topics. Try to complete the key modules and perhaps one or more in each of the process areas.

WHERE TO BEGIN

Kindergarten

Stages I to IV on the *Planning Chart* are appropriate for this level. Stage I consists of Modules 1, 2, 6, and 7. You may begin with any one of these modules. In this way four teachers can be working on Stage I, each teaching a different module. This allows for flexibility in scheduling, sharing, and planning the program. After the children have completed the modules at Stage I, they can proceed to any of the modules at Stage II.

Another way of teaching this program is to start with one of the four clusters, colored red, green, brown, and orange. Proceed from the first to the last stage within the cluster. When you have finished, select another cluster.

Grade One

Modules 16 to 30 are designed for a typical first grade. On the *Planning Chart* these appear in Stages V to VIII. You can start with Stage V and move on to each successive stage after the modules within each stage are completed. For children who lack any previous work with this program, teach DEBUT Modules 2 and 12 first.

You can also effectively teach the program by starting with one of the three clusters in this group and moving from stage to stage. When one cluster is completed, the children can start work on another cluster.

Grade Two

With careful instruction, the children should be able to complete Modules 31 to 45. You can start with Stage IX on the *Planning Chart* and move through each successive stage through Stage XII. Students who have entered the program at this time can catch up on prerequisite skills by first doing DEBUT Modules 18, 24, 25, 26, and 27.

Another successful approach is to work successively on modules within one of the eight clusters in this level. When one cluster is completed, the children can proceed to another cluster.

Grade Three

Modules 46 to 60 are designed for this grade level. If the children have acquired all the prerequisite skills, you can start at Stage XIII with Modules 46, 47, 48, or 49. Proceed to each succeeding stage through Stage XVII. For those who have just started the program, or who may need additional review, prerequisite skills can be learned by first working on DEBUT Modules 24, 33, 38, and 39.

Module 52 introduces skills in graphing, which are needed throughout the program. Students are referred to the auto-instructional booklet *Making a Line Graph 1.*

Grade Four

Students should work successfully at Modules 61 to 75, in Stages XVIII to XXI, assuming they have mastered the prerequisite skills. For those who are entering the program at this time, the following DEBUT modules should be taught first: Modules 24 and/or 59, 39, 46, 47a, and 53. Time may not permit you to complete all fifteen modules at this level if you must teach the DEBUT modules. If this is true, select modules in key clusters for the most effective results.

References to graphing skills are made in Modules 66, 68, 70, 71, 72, 73, and 75. Students are referred to *Making a Line Graph 2* and *3*, which reinforce and extend basic skills in graphing.

Grade Five

Modules 76 to 90 are appropriate for this grade level. For students who have had no prerequisite skills, the following DEBUT modules should be completed first: 39, 46, 59, 61, 62, 63, 64, 70, and 75. If these back-up modules must be used, the children may not be able to complete all the modules in this level. Select modules in key clusters to provide a comprehensive background in the integrated processes.

Graphing is a necessary skill in Modules 76, 77, 78, 80, and 82. The children are referred to the auto-instructional booklets *Making a Line Graph 2* and *3* for review and practice of these skills.

Grade Six

Modules 91 to 105 are designed for this grade level. You can start with Stage XXVII and proceed to each successive stage until XXXIII. Or you can teach the modules by cluster, moving successively from one stage to the next within a given cluster.

There are no DEBUT modules for this grade level. Instead, the first five modules are review modules. This means that students can review all prerequisite integrated skills up to this level. For groups that are using this program for the first time, Modules 91 to 95 provide some background; however, care should be taken to ensure minimum skills in measuring with the metric system.

Graphing skills are required in Modules 93, 94, 96, 98, 99, 100, 103, and 105. Students are referred to the auto-instructional booklets *Making a Line Graph 2, 3,* and *4* for review and extension of skills.

EVALUATION

Evaluation has been built into SCIENCE ... A PROCESS APPROACH II from its inception. Behavioral objectives are stated for each exercise. To determine if every child has achieved these objectives, each exercise contains a *Competency Measure.* It is a basic tenet of this program that evaluation is an intrinsic part of the learning process.

Teachers can evaluate the progress of individuals as well as groups of children. *Tracking Cards* are one means of keeping track of each child's progress. Evaluation results can be recorded either in pencil or by punch-card coding. The inside of the card can be used for planning or charting an individual's progress through the modules. *Competency Measure* results can be recorded in the space below each module description.

One *Tracking Card* covers the basic processes (Modules 1 through 60). Another card covers the integrated processes (Modules 61 through 105). The cards can be stored in a record file and used as a reference when necessary.

The following is a checklist for evaluating the progress of your students:

1. Use the *Sequence* chart on the first page of each *Instruction Booklet* to determine whether or not the children have the prerequisite skills; if not, provide the appropriate DEBUT modules, or review the module objectives identified as prerequisite.

2. After the module has been taught, administer the *Appraisal* activity (Modules 1-60) or the *Group Competency Measure* (Modules 61-105) to measure the achievement of objectives by a group of children.

3. Administer the *Individual Competency Measure* to a small group of pupils for each module. In selecting students, you may wish to include some from the high- and some from the low-achiever groups and some from the group that you feel least certain about. This evaluation device may be waived if evidence warrants it.

4. Keep an individual profile sheet for each pupil, even though you do not have a competency score on each objective for each pupil. Many tasks can be scored from your observation of investigations by individuals and small groups of children, without use of the *Competency Measures. Tracking Cards* can be used here.

5. Keep an anecdotal record or diary of significant events in your teaching (failures as well as successes), including the involvement of individuals by name.

6. Administer check-point tests and end-of-the-year science tests if you like. Choose tests that measure individual performance rather than memory of facts.

7. Report to parents on the progress of their children in achieving competence in the processes of science. *Tracking Cards* may be discussed in conferences with parents. In the periodic reports of student progress made in most schools, inclusion of statements about skills in the processes of science would be interesting and helpful to parents.

8. Encourage parents to report their children's comments on science experiences in school.

9. If your school requires reporting by letter or numerical grade, the *Tracking Cards* will provide an adequate basis for determining the children's grades. Devise scales that are appropriate for your school and for your groups of children.

10. Finally, the anecdotal record referred to in Step 5 can serve as a basis for describing student interests, attitudes, and character development. The use of varied instructional modes in SCIENCE ... A PROCESS APPROACH II will help children see that learning can be fun, and that it sometimes proceeds best when you work with friends in one way or another.

The behaviors observed as the children proceed through the modules should help the students develop positive attitudes about discovery and inquiry, as well as to point out that rational, honest thinking is based on inferences and predictions derived from observations.

RELATIONSHIPS WITH OTHER SUBJECTS

Ample evidence that the science activities of SCIENCE . . . A PROCESS APPROACH II can be related to other subjects in the curriculum has come from teachers who have tested the revised edition with children.

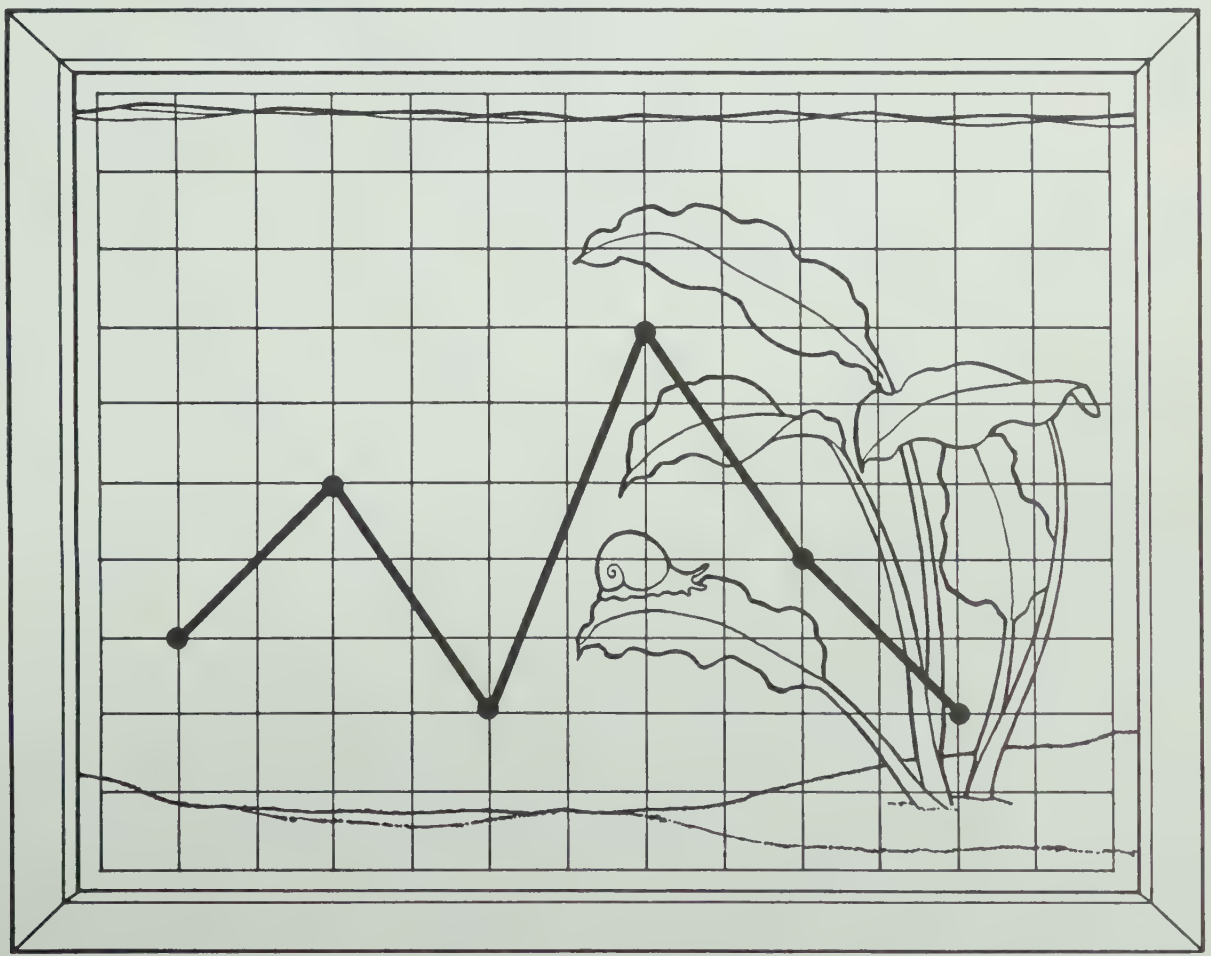
Teachers, particularly those in the primary grades, have commented frequently on the relationship of science activities to the language arts. Children become interested in reading books related to their science activities; they write poems and stories about things in an aquarium, or about the weather, or about mold gardens. They communicate orally, and, as they describe their observations, they increase their abilities to use descriptive and comparative terms. One teacher commented that during the instruction of the module *Symmetry*, the children identified the symmetrical letters of the alphabet and that this helped them make the letters more carefully in their writing.

Graphing is used throughout the program as a technique for recording and communicating information. Graphing is an important part of mathematics and is also used in social studies. One teacher found a use for it in independent reading: The children's delight in watching their bars on the graph grow each time they finished reading a book was a real motivation for reading.

Art is another subject that the teachers found could be related easily to many science activities. In the module *Molds and Green Plants,* the children draw pictures in color to record the growth of mold. In other modules, such as *The Bouncing Ball* and *Relative Motion,* the children may draw pictures that show objects in motion. The modules *Optical Illusions* and *Eye Power* have led to art activities. Some children have enjoyed drawing pictures of the crystals they have prepared in the module *Working with Solutions.* This last module led one teacher into a social studies activity on water purification.

Social studies activities can be related to many modules in the program. For example, the modules *Weather* and *Temperature and Thermometers* lead readily to study the effect of climate on culture; the module *Surveying Opinion* has obvious value in the democratic process; the module *Chemical Reactions* might lead to consideration of the economic cost of rusting in automobiles.

In almost every module in SCIENCE . . . A PROCESS APPROACH II, the imaginative teacher will find opportunities to relate the science program to other curricular and extracurricular activities of the children.



WHAT DOES IT ALL ADD UP TO?

What will "graduates" of SCIENCE . . . A PROCESS APPROACH II be like? What will they know? How will they approach new problems? What will they be able to do? As the program developed, the authors grappled with these questions. The answers to these questions became the goals of the program. At the end of the program the student should be able to:

(a) Apply a scientific approach to a wide range of problems, including social ones, distinguishing facts from conjectures and inferences, and identifying the procedures necessary for verification of hypotheses and suggested solutions.

(b) Acquire an understanding of the sciences he or she will pursue in junior and senior high school more rapidly and with less difficulty than would otherwise be possible.

(c) Identify each of the following in a printed or oral account of a scientific experiment: the question being investigated; the variables manipulated, controlled, and measured; the hypothesis being tested; the relationship of such a test to the results obtained; the conclusions that can legitimately be drawn.

(d) Infer, where necessary, the question being investigated and the elements of scientific procedure in an incomplete account of a scientific experiment, such as might appear in a newspaper.

(e) Design and, under certain conditions, carry out one or more experiments to test hypotheses relevant to a problem, providing the problem is amenable to scientific investigation and the content is within the child's understanding.

(f) Show appreciation of, and interest in, scientific activities by choices made in reading, entertainment, and other kinds of leisure-time pursuits.

(g) Develop values, attitudes, value systems, and value judgment criteria not only applicable to science-related experiences but transferable to day-to-day experiences throughout life.

These are things that should happen. If and when they do, the important goals of SCIENCE . . . A PROCESS APPROACH II will be achieved.

INSERVICE PROGRAMS

To teach SCIENCE . . . A PROCESS APPROACH II successfully, teachers must feel comfortable with the program. Teachers may want to sharpen their skills in observing, measuring, controlling variables, and other processes. They may wish to refresh their backgrounds in science. Or they may want some guidance in efficient management of individual and small-group science activity. A variety of ways are available for providing inservice training for teachers.

Orientation Package

The *Orientation Package* consists of a series of five sound filmstrips which provide instruction in the scientific processes and teaching strategies found in the program. Special latent-image worksheets permit immediate evaluation of responses made during the filmstrip showings. The filmstrips are titled as follows:

Filmstrip 1: Introduction to SCIENCE . . . A PROCESS APPROACH II
Filmstrip 2: The Basic Processes
Filmstrip 3: The Metric System
Filmstrip 4: The Integrated Processes
Filmstrip 5: Teaching Strategies

The filmstrips and cassettes have been designed for flexible use. They are appropriate for either pre-service or inservice group settings. They can also be used for self-instruction by an individual teacher at his or her leisure. The *Orientation Package* is also valuable for review purposes as the need arises.

Commentary for Teachers

The *Commentary for Teachers* was prepared for use by individual teachers. The *Commentary* consists of a collection of self-instructional units in workbook form, all designed to give teachers experience and instruction in the processes of science. Included are many papers that explore a variety of content areas in depth.

It is recommended that each teacher have a copy of the *Commentary,* or have ready access to a copy located in a central place. Teachers will find this book very useful when preparing to teach any module of SCIENCE . . . A PROCESS APPROACH II.

Guide for Inservice Instruction

The *Guide* consists of modules structured like those in the *Instruction Booklets.* The *Guide* has been prepared to assist the inservice program instructor. Of 21 modules, thirteen deal with the processes of science, one deals with reading exercises for use in the middle grades, and the remaining seven treat instructional strategies. In addition to the *Guide* for the instructor, there is a set of *Response Sheets* for the teacher participants and two forms of a *Process Measure for Teachers.*

Research

Science . . . A Process Approach has stimulated a large number of research studies conducted by persons not associated with the development of the program. These investigators have been interested in various aspects of the science program. However, four major topics have been examined most frequently: (1) student achievement, (2) the effect *Science . . . A Process Approach* has on reading readiness, (3) process skill acquisition, and (4) change in teachers.

Student Achievement

Success motivates success. An early goal of the program was that 90% of the children should achieve 90% of the objectives. It was with this aim in mind that the developers of *Science . . . A Process Approach* designed and tested each of the competency measure tasks written for each exercise. If the competency measure tasks of an exercise were not completed at a high level by most of the pupils in the tryout programs, the exercise was modified or deleted and another substituted in its place. In some instances, the competency measure was revised because it was at fault. Therefore, it is not surprising that independent report data show that students score correctly on more than eight out of every ten of the competency tasks they attempt (ERIE, 1971; Torop, 1972).

Additional studies have been done which relate specifically to disadvantaged students and their success in science. Huff (1971) found that disadvantaged kindergarten children's participation in *Science . . . A Process Approach* enhanced development of oral communication skills. McGlathery (1968) found that students from lower socioeconomic backgrounds did not do as well as middle-class students where evidence of science achievement required the students to verbalize. However, socioeconomic backgrounds could not be used as predictors of success when science achievement was based on nonverbal behavior. Much of the student assessment in *Science . . . A Process Approach* is nonverbal.

Pierce (1968) found that *Science . . . A Process Approach* experiences can be used successfully to enhance intellectual development in preschool children, and that low-I.Q. children achieved as well as the higher-I.Q. children in her study. Thus the studies of Huff (1971), McGlathery (1968), Pierce (1968), and the work of Zerr (1970) all demonstrate that *Science . . . A Process Approach* can be used successfully with the socially disadvantaged.

Teachers generally must consider the readability of a science program. However, since *Science . . . A Process Approach* does not have student texts, the teacher is not confronted with the problem of matching the reading level of a text to the many reading levels found in the class. Instead, he or she may select from related reading materials those topics that are interesting and comprehensible to a particular class. These materials can then serve as a motivational tool.

Reading Readiness

Several very interesting reading readiness studies have been done with primary age children. Ritz and Raven (1970) found that *Science . . . A Process Approach* in the kindergarten program did not impair reading readiness and did increase science process skills. Ayers and Mason (1969) found that kindergarten children exposed to *Science . . . A Process Approach* made higher scores on the *Metropolitan Readiness Test* than those not exposed to it. Such studies would indicate that *Science . . . A Process Approach* can serve as a vehicle to teach process skills while promoting reading readiness.

Process Skill Acquisition

Since process skill development is considered of primary importance to children in the elementary grades, a number of studies relating *Science . . . A Process Approach* students show a better understanding of process skills than students under a traditional science program which does not include activities where materials are manipulated.

Change in Teachers

Involvement with *Science . . . A Process Approach* does effect change in teachers. For example, in administering competency measures, *Science . . . A Process Approach* teachers gain in their knowledge of how children perceive and attack problems (Atwood, Brown, Neal, 1972). In another analysis, as a result of classroom instruction and inservice education, the teachers demonstrated an increased knowledge of process skills, a change in their ways of making decisions about instructional procedures, and a more positive attitude toward the program (Wideen, 1972; Breit, 1969).

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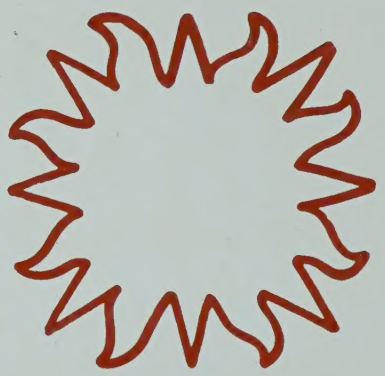

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